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AUTHOR Witters-Churchill, Laurie J.; Witters, Lee A.
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ABSTRACT

The paper provides an analysis and synthesis of studies with hearing impaired and other populations concerning the cognitive development of the principle of liquid horizontality--the idea that still water remains invariantly level regardless of the angle of the container. Three major questions focused the investigation: (1) What are the effects of development on students' performance on the Piagetian liquid horizontality test? (2) Do special training and shape of bottle influence the students' performance on the test? (3) What effects of gender are found on the students' performance on the test? Results suggested that hearing impairment has little impact on the development of this cognitive concept; that training in scientific reasoning with hands-on experiments improved performance in hearing impaired as well as other groups; and that sex differences in development of the concept appear to exist in normal but not exceptional (including hearing impaired) groups. Implications for instruction include the value of multisensory experiential learning for all groups and the need to minimize sex stereotypes. Recommendations include: that researchers provide sufficient information to allow replication, that research journals publish nonsignificant findings, that a meta-analysis be conducted to determine the magnitude of reported sex differences, and that more studies with exceptional populations be conducted. (DB)

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HEARING-IMPAIRED STUDENTS' PERFORMANCE ON THE PIAGETIAN LIQUID HORIZONTALITY TEST: AN ANALYSIS AND SYNTHESIS

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Laurie J. Witters-Churchill, Ph.D.
Texas A & M University

Lee A. Witters, Ed.D.
University of Nebraska-Lincoln

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Abstract

Numerous studies have been conducted involving the principle of liquid horizontality--the idea that still water remains invariantly level regardless of the angle of the container. Piaget and Inhelder (1956) viewed a child's success on this type of task as a function of his or her level of cognitive development because it tests the ability to use external frames of reference.

Robertson and Youniss (1969) and Watts (1979) reported similar performance patterns for hearing-impaired and normal-hearing children in their perception of liquid horizontality. Furth (1973) argued that the results obtained by Robertson and Youniss indicated that a lack of linguistic experience has no substantial impact on a child's understanding of spatial transformation.

Of particular interest in the recent horizontality studies has been the finding that normal-hearing females from primary to college level appear to have greater difficulty than normal-hearing males in perceiving and understanding the principle that still liquid remains invariantly horizontal (Kelly & Kelly, 1977, 1978a, 1978b; Kelly & Witters, 1981; Liben & Golbeck, 1985; Morris, 1971; Rebelsky, 1964; Thomas & Jamison, 1975; Thomas, Jamison, & Hummel, 1973; Williamson & Reynolds, 1973). Recently the examination of sex differences in the perception of liquid horizontality has been extended to include exceptional populations. Three such studies examined hearing-impaired students (Murphy-Berman, Witters, & Harding, 1985, 1986; Witters-Churchill, Kelly, & Witters, 1983). Interestingly, contrary to studies with hearing subjects, no consistent pattern of sex differences was found. Similarly, no consistent sex differences in the perception of liquid horizontality were detected in recent studies of adolescents with social-emotional problems and of learning disabled students (Murphy-Berman, Witters, & Schillerstrom, 1987; Murphy-Berman & Witters, 1987).

Why sex differences would be found with "normal" but not with "exceptional" populations is open to speculation. Witters-Churchill, Kelly, and Witters (1983) speculate that perhaps hearing-impaired students' lack of linguistic sophistication shields them from some of the subtle gender biases present in the language, thereby suggesting that gender-related differences reported in previous studies with normal hearing students may have more of a social learning (or experiential) than a genetic (or biological) basis.

The purpose of this paper is to provide an analysis and synthesis of the studies which have been conducted with hearing-impaired populations. Further, these studies of hearing-

impaired students will be compared to studies of other exceptional populations and to normal-hearing populations. Meta-analysis will be used to summarize and compare these data. Through this type of analysis, a clearer explanation of the questions under investigation may be found.

Introduction

Piaget and Inhelder (1956) examined from a developmental perspective whether or not children understood the concept of liquid horizontality--the principle that the surface of still water remains horizontal regardless of the tilt of the jar. They were primarily concerned with children's ability to utilize external frames of reference for locating and comparing the positions and orientations of objects in space. Piaget asserted that this skill is critically important to a child's cognitive development because "far from constituting the starting point of spatial awareness, the frame of reference is in fact the culminating point of the entire psychological development of Euclidian space" (Piaget & Inhelder, 1956, p. 417).

Piaget and Inhelder (1956) viewed a child's success on this task as a function of his or her level of cognitive development. They suggested that this concept emerges by the age of nine or ten years, but is not fully achieved until late childhood (approximately age 12) concurrent with the development of concrete operations. They believed that this concept is an important milestone in a learner's cognitive development, since this skill is essential in the areas of science, mathematics, and geography (Copeland, 1979).

Numerous studies have since been conducted involving the principle of liquid horizontality, which can be utilized to test the ability to use external frames of reference. Developmentally, it has been consistently demonstrated that children below the age of nine have considerable difficulty in perceiving and understanding this concept (Barna & O'Connell, 1967; Beilin, Kagan, & Rabinowitz, 1966; Ford, 1970; Kelly & Witters, 1981; Piaget & Inhelder, 1956; Shantz & Smock, 1966).

Recently, there has been increased interest in cognitive achievement and sex-related differences, particularly in the areas of mathematics and science. Although Piaget did not discuss sex differences, a number of studies have reported that females appear to have considerably more problems than males in perceiving and understanding that liquid remains invariably horizontal. Sex differences on this task have been documented with the adult population (Morris, 1971; Rebelsky, 1964; Willemsen & Reynolds, 1973), college students (Kelly & Kelly, 1977, 1978a; Thomas & Jamison, 1975; Thomas, Jamison, & Hummel, 1973; Walker & Krasnoff, 1978), and with elementary and junior high level children from both regular and gifted educational programs (Kelly & Kelly, 1978b; Kelly & Witters, 1981).

A meta-analysis of studies involving several spatial perception tasks (e.g., Rod and Frame Test, Horizontality task) conducted by Linn and Petersen (1985) revealed that males do perform in a superior manner to females on these tasks, with effect-size differences ranging from one-third of a standard deviation unit for subjects under age 18, to two-thirds of a standard deviation unit for those over 18. Linn and Petersen noted, however, that the studies they reviewed revealed that only about 5% of the variance in the water level task is attributable to sex. Nonetheless, an explained variance of 5% may be of practical significance when examining multivariate issues in the behavioral sciences.

Few studies examining the principle of horizontality have been conducted with "exceptional" populations, but those that have been done yielded some differences in these previously-reported patterns of sex differences. In studies with hearing-impaired students by Witters-Churchill, Kelly, and Witters (1983) and Murphy-Berman, Witters, and Harding (1985a, 1985b, and 1986), for instance, the researchers reported that either no sex differences were found or that fewer differences across test items emerged. This result was true for both

elementary and secondary level hearing-impaired students and for children who were labeled as gifted hearing-impaired. In addition, no sex differences were reported in a study with adolescents with severe emotional-social problems, commonly labeled behavioral disordered (Murphy-Berman & Witters, 1987), nor with elementary and secondary learning-disabled students (Murphy-Berman, Witters, & Schillerstrom, 1988). Why sex differences would be found with "normal" but not with "exceptional" populations is open to speculation.

Purpose of the Study and Major Questions

The present study analyzed and synthesized the current research which has been conducted in the area of hearing-impaired students' understanding of the liquid horizontality principle. These data were compared to data from normal-hearing populations and from other exceptional populations. A limited application of the meta-analysis procedure (Glass, 1986) was used. Three major questions focused the investigation:

1. What are the effects of development on students' performance on the Piagetian liquid horizontality test?
2. Do special training and shape of bottle influence the students' performance on the test?
3. What effects of gender are found on the students' performance on the test?

The intended outcome of this type of study was to develop further an explanatory framework for the differences in performance on the horizontality task among hearing-impaired and normal-hearing populations, particularly in the area of sex differences.

Value of This Study

This type of cognitive research is potentially interesting to educators, psychologists, and other professionals working with the hearing-impaired, for several reasons. First, it involves both visual-spatial and language-concept tasks. For adolescents and adults, it is highly probable that the visual-spatial task of drawing a water line correctly for various bottle rotations also involves considerable language mediation. Luria (1966, 1973) contended that the speech/language function regulates all the higher mental functions, including perception, once the prefrontal regions of the cortex begin to mature around the ages of four to seven years. It is a generally accepted assumption that deaf and hearing-impaired persons are at a disadvantage in terms of formal language comprehension, language production, and speech. A subject of controversy for a long time has been the intellectual ability of deaf children. One view holds that deafness results in deficient conceptual ability because thought depends upon language. Another view argues that thought is possible without language. Generally, however, psychologists and educators have frequently equated cognitive abilities with language. Second, considerable developmental data are available for normally-hearing subjects, giving a solid perspective on how people at different ages should perform these tasks. Studies testing aspects of the Piagetian theory of cognitive development with deaf children as compared with hearing subjects might challenge some accepted assumptions about how deaf children learn and, subsequently, their instruction and academic achievement. Finally, it can contribute to the knowledge base concerning the influence of a severe hearing loss on the cognitive processes identified by Piaget and others in numerous follow-up studies. There is a need to build continually on previous cognitive research with hearing-impaired and other special populations.

In addition to being of interest to professionals working with the hearing impaired, an analysis and synthesis of research such as this area involving exceptional populations provides an expansion of the existing data base and therefore broadens the explanatory framework for sex differences in cognition. By using meta-analysis, a method for synthesizing empirical studies (Glass, 1976), the research questions which have been studied extensively may be clearly summarized. This type of summary will allow the reader to draw her or his own conclusions and evaluate the implications.

Methodology

For purposes of this paper, analysis and synthesis focused on studies involving exceptional populations. The number of studies found which had investigated the perception of liquid horizontality using exceptional populations, particularly with the hearing impaired, was very small. This limited selection of studies was analyzed in depth and was compared to the larger data base of existing studies on hearing populations.

An extensive literature search was conducted to identify studies appropriate for the present investigation. The primary data base for this search was the Educational Resources Information Center (ERIC); additionally, reference lists from relevant published articles were perused and the authors' personal files were searched. To be included, a study needed to meet these criteria: (a) subjects involved exceptional populations; (b) some form of liquid horizontality test was used; (c) quantitative data were provided; (d) data to calculate effect size and/or explained variance were included; and (e) information given was related to at least one of the major questions being considered.

After studies that met topical criteria were located, they were read for variables relating to the research questions. The following variables were noted: (a) developmental data; (b)

training data; (c) gender data; and (d) test data. Each study was reviewed individually and results were examined to ensure that separate samples were reported. For example, although six published and unpublished articles and theses were located in the literature in which hearing-impaired subjects were under investigation, these articles reflected only four separate studies.

This search resulted in the discovery of only seven separate research studies which have investigated the liquid horizontality concept with exceptional populations. Of these, four studied hearing-impaired subjects (Murphy-Berman, Witters, & Harding, 1985a, 1985b, and 1986; Robertson & Youniss, 1969; Witters, 1980; and Witters-Churchill, Kelly, & Witters, 1983), one studied gifted subjects (Kelly & Witters, 1981), one studied adolescents with severe emotional-social problems (Murphy-Berman & Witters, 1987), and one studied learning-disabled subject (Murphy-Berman, Witters, and Schillerstrom, 1988). Unpublished studies which were located were deliberately included in the synthesis in order to diminish to some extent the concern that available studies are biased toward significant effects while other studies remain in the file drawer (Rosenthal, 1979). Table 1¹ summarizes the studies located which investigated liquid horizontality with exceptional populations.

Twenty-three studies involving investigation of the liquid horizontality principle with hearing populations were reviewed for comparison purposes. These are discussed in the results section and are listed in the references.

The researchers in the present study were particularly interested in the finding that sex differences in performance on the liquid horizontality test have been documented in "normal" populations but not in "exceptional" populations. Therefore, a major purpose of this study was

¹ Tables are placed at the end of the article before references.

to re-analyze the studies on cognitive gender differences with both "normal" and "exceptional" populations, and to report the magnitude of differences that exist between those "exceptional" males and females.

Typically, the measure $d = \frac{M1 - M2}{SD}$, where $M1$ and $M2$ are the means of the two groups and SD is the average of the standard deviation of the two groups, is used to report "effect size." For purposes of interpretation, Cohen (1977) considers a d of 0.20 to be small, a value of 0.50 to be medium, and a value of 0.80 to be large. An effect size of 0.50, for example, means that one group differed from the other by one-half a standard deviation.

Another measure of effect size which is frequently used by researchers to report magnitude is omega-squared (Ω^2). This measure was used to identify the proportion of the total variance in the population that was accounted for by gender differences. McNamara (1978) transformed the frequently-used formula by Hays (1963) so that this measure may be calculated using statistics commonly reported in research journals (i.e., $\bar{E}$, N , and n) and does not require a complete ANOVA table. From this calculation, the practical significance of the findings may be interpreted. Effect size d and omega-squared (Ω^2) were reported when sufficient information was provided.

Results and Discussion

For each of the three major research questions, results will be presented as follows: first, a brief summary of the literature pertaining to normal-hearing populations will be discussed. Next, the results of the studies involving exceptional populations will be detailed, with special emphasis on those studies which examined hearing-impaired learners. For those studies of exceptional populations which considered the gender question and which reported

sufficient data for calculation effect size values d and omega-squared (Ω^2), together with the probability value p , are summarized in Table 2.

1. Development

For normal-hearing students, numerous studies suggested that children younger than nine have difficulty in perceiving and understanding that liquid remains invariantly horizontal.

For those exceptional populations commonly labeled learning-disabled and those who are gifted, older (secondary) students did better than did younger (elementary) students (Murphy-Berman, Witters, & Schillerstrom, 1988; Kelly & Witters, 1981), thereby suggesting that these children are similar to normal children in development according to the Piaget stages. The study by Murphy-Berman and Witters (1987) with adolescents with social-emotional problems did not address the developmental variable.

For the hearing-impaired population, Robertson and Youniss (1969) examined hearing-impaired and hearing children's abilities to perceive the horizontality of water level for two age groups: 8 to 9 years and 11 to 12 years. Their study showed similar patterns between the two groups. The younger but not the older hearing-impaired children performed significantly lower than the hearing subjects. Post-tests following training revealed no differences. Furth (1973) argued that the results of the Robertson and Youniss study indicated only a slight retardation on the part of hearing-impaired children and concluded that a lack of linguistic experience has no substantial impact on a child's understanding of spatial transformation. The Murphy-Berman, Witters, and Harding study (1985b and 1986) reported that for a comparable hearing-impaired age group the performance was similar to secondary-level hearing-impaired students and argued that primary and intermediate-level deaf students may possess this type of spatial transformation in a manner quite similar to their older peers. If additional studies support this

conclusion, a lack of linguistic experience would have little impact upon hearing-impaired elementary and secondary students' understanding of this cognitive concept.

2. Training

An examination of selected studies related to the principle of liquid horizontality revealed that the bottle shapes of the test instrument varied (rectangular jars, flasks, beakers, curved surfaces). Generally speaking, the shape of the bottle used in the test stimuli influenced performance; for example, some students did better with curved surfaces than with rectangular. Therefore, conclusions are tentative at best. However, in those studies using specific training activities with normal populations, student performance on the test improved.

As for exceptional populations, training improved performance for elementary and secondary gifted students (Kelly & Witters, 1981), for adolescents with social-emotional problems commonly labeled behavioral-disordered (Murphy-Berman & Witters, 1987), for elementary and secondary learning-disabled students (Murphy-Berman, Witters, & Schillerstrom, 1988), and for secondary hearing-impaired students (Witters, 1980; Witters-Churchill, Kelly, & Witters, 1983). These studies conducted with hearing-impaired students utilized a non-verbal training procedure in which the principle was demonstrated using visual aids.

3. Gender

Females from a variety of normal populations have been found to have more difficulty than males in perceiving and understanding then principle of liquid horizontality. Researchers have speculated that cognitive sex differences observed in hearing populations on the horizontality task and on other tasks may be due to either biological or experiential factors. Among the biological hypotheses considered have been difference in genes (Bock & Kolakowski, 1973; Thomas, 1983; Vandenberg & Kuse, 1979), hormones (Berenbaum & Resnick, 1982; Petersen, 1979), brain structure and function (McGlone, 1980; Petersen, 1982),

and timing of puberty (Newcombe & Bandura, 1983; Petersen, 1983). Hypotheses concerning the effects of experiential factors and socialization processes on cognitive sex differences have included expectancies for success (Meehan & Overton, 1986), parental expectations (Parsons, Adler, & Kaczala, 1982), educational policies and practices (Fox, Tobin, & Brody, 1979), and academic experience (Kalichman, 1987).

Petersen (1982) cautions that while sex is a simple and easy-to-measure variable, it is clearly not simply genetic or even biological in nature. Therefore, she recommends that investigations or sex-related differences not be limited to one subset of plausible explanations. That is, if only biological factors are studied, erroneous conclusions about the source of variance may be derived. For example, Petersen emphasized in her discussion of brain structure that a biopsychosocial, rather than a genetic-only or even biologic analysis alone, is probably warranted. In any case, it is important to examine cognitive sex differences from a multivariate perspective and to attempt to identify potential sources of explained variance.

No sex differences were noted in studies with hearing-impaired and gifted hearing-impaired subjects (Murphy-Berman, Witters, & Harding, 1985a, 1985b, and 1986; Witters, 1980; Witters-Churchill, Kelly, & Witters, 1983). When similar studies were conducted with adolescents with social-emotional problems (Murphy-Berman & Witters, 1987) and with elementary and secondary learning-disabled (Murphy-Berman, Witters, & Schillerstrom, 1988), once again no sex differences were noted. Table 2 provides a summary of the studies of exceptional populations which addressed the gender issue. Effect size d , probability value p , and omega-squared (Ω^2), are reported and demonstrate the lack of variance which can be accounted for by sex.

Why sex differences would be found with "normal" but not with "exceptional" populations is open to speculation. It has been hypothesized by the authors in previous

research (see Murphy-Berman & Witters, 1987; and Murphy-Berman, Witters, & Harding, 1985) that socialization differences among these populations may contribute to some of the different patterns of findings obtained. Murphy-Berman and Witters (1987) believed that these differences in socialization experiences may influence or contribute to the lack of gender differences in adolescents with social-emotional problems. Because hearing-impaired and behaviorally-disordered children are both somewhat removed from the cultural mainstream by virtue of their language and/or behavioral problems, both groups may be less subject to the potentially biasing influences of this mainstream socialization. Learning-disabled male and female students may be similarly isolated from stereotypic cultural expectations by their shared status as "exceptional children." It is also possible that the difficulty that the learning-disabled students may have in conceptualizing problems that require visual-spatial competence reduced the potential for the emergence of sex differences on this task.

Witters-Churchill, Kelly, and Witters (1983) speculated that perhaps hearing-impaired students' lack of linguistic sophistication shields them from some of the subtle gender biases present in the language, thereby suggesting that gender-related differences reported in previous studies with normal-hearing subjects may have more of a social-learning (or experiential) than a genetic (or biological) basis. This possibility is intriguing and could be explored by assessing sex differences among hearing-impaired students on a wider variety of spatial tasks where hearing males have traditionally performed at a high level than hearing females. Williams (1985) suggested that the non-significance in these studies may be due to a lack of statistical power to detect a true difference as a result of the small sample sizes and the degree of variability within the deaf population. Witters-Churchill, Kelly, and Witters (1983), however, reported that the power to detect gender differences in their study was 0.88, which should be considered sufficient to detect a significant difference if it did indeed exist. Thus, the conclusions about no

significant differences in gender performance seem justified, at least tentatively. These data support the notion argued by Petersen (1982) and others that the gender-related differences reported in previous studies with "normal" populations may have more of a social-learning (or experiential) than a genetic (or biologic) basis (see Maccoby & Jacklin, 1974), and that a biopsychosocial model of explanation may be the most appropriate.

Implications

Several important implications for both instruction and research are apparent from this study. Instructional implications may be of concern to educators of both hearing-impaired and normal-hearing learners. Research implications address methodological concerns and directions needed in future research.

Implications for Instruction: Exceptional Learners

Several general recommendations about instruction of exceptional learners can be made upon the analysis presented above. First, it appears that training hearing-impaired and other exceptional children and youth in scientific reasoning with controlled hands-on experiments increases their understanding of the process of scientific investigations. Experimenting in the classroom is recommended to observe whether exceptional learners, including the hearing-impaired, accelerate or elaborate their learning on visual-spatial tasks to show their ability for learning required material and for generalizing to other situations with less effort than learning specific lower-order subject skills. Organizing the relationship of objects in space is essential to the study of a variety of academic subjects, such as geography and mathematics, and requires an ability to utilize spatial reference cues.

Second, providing multisensory approaches utilizing visual, auditory, and tactile stimulation with exceptional learners likely maximizes learning. The synthesized data suggest that hearing-impaired children can begin to appropriately represent spatial relationships at an

early age, but they need practice in learning to disregard distracting spatial cues. Applying visual-spatial tasks to daily living situations strengthens exceptional learners' understanding of basic concepts in math, science, and geography. Provision of an environment in which learners can solve problems and self-regulate their own learning would appear to be desirable. This self-paced instruction suggested the need for use of inductive approaches to teaching and learning in order to lay the groundwork that would help hearing-impaired and other exceptional students comprehend more abstract spatial principles.

Working cooperatively with others on the visual-spatial tasks in the learning environment seems desirable for language development. It seems important, for instance, to combine verbal ability with manipulation. Verbal ability is not always equal to functional ability, as demonstrated, for example, by young gifted students who were able to state the rule for the horizontality principle, but who were unable to complete the functional task. On the other hand, some learning-disabled students were able to draw the horizontal water line but were unable to verbalize the rule. In the case of hearing-impaired learners, verbal ability (i.e., ability to state the rule of horizontality) was related to functional ability (i.e., ability to draw the horizontal water line), but was not always equal. Functional ability improved after non-verbal methods of training were provided.

A note of caution is important at this time. These limited studies on hearing-impaired and other exceptional students' performance on the Piagetian liquid horizontality test would seem to suggest that these learners may benefit more from educational programs designed for broader cognitive development rather than programs aimed at specific rote skills. This generalization should not be accepted uncritically. Piagetian theory in classroom practice, such as activity learning and self-discovery approaches, might seem exciting for the teacher of these

students. However, these studies need to be replicated and additional research undertaken before these implications for instruction are automatically accepted.

Implications for Instruction: All Learners

The pattern of results reported in this study suggests that hearing status, per se, may not be as influential a factor in affecting an individual's ability to make these specific types of spatial transformations as are other cognitive and experiential factors that cut across hearing/non-hearing dimensions. Even those studies of hearing populations, it has been argued, have not shown that sex accounts for more variance than do other factors. Given the likelihood that socialization processes account for sex differences in performance on some tasks, recommendations to reduce this negative socialization are warranted.

First, educators should minimize sex stereotypes in order to diminish the potential for a self-fulfilling prophecy; for example, older girls are less likely to see the need for advanced training in mathematics due to these negative stereotypes. Second, students should be exposed to a multitude of ideas, experiences, and models and be provided experiences conducive to self-differentiation and self-knowledge. Finally, educators should teach skills for making choices, solving problems, and evaluation.

Implications for Future Research

The review of studies involving liquid horizontality research, including those with both hearing and hearing-impaired subjects, revealed the importance of reporting complete statistical data. Several studies had to be excluded from synthesis because inadequate data were reported for calculating effect size and the explained variance. Providing sufficient information to allow replication would increase credibility for educational research as well as facilitate meta-analysis and other empirical syntheses of existing knowledge. Specifically, studies should include: (a) sample size specification, (b) problem statements and research hypotheses, (c) exact probability

values associated with the test of each statistical hypothesis, (d) measurement concerns associated with reliability and validity, and (e) complete data results that correspond to the conclusions entered in the published report.

Additionally, prejudice against the null hypothesis in published journals has been discussed and documented. It is therefore recommended that research journals publish non-significant findings, and that all significant findings include measures of practical significance. Specifically, it is recommended that a meta-analysis procedure be conducted with the 23 studies of hearing subjects identified in the present literature search, in order to determine the magnitude of sex differences which have been reported.

Finally, more studies with exceptional populations are needed to expand the existing data base. These studies should continue to measure students' perception of liquid horizontality and should also extend to other measures of cognition in order to support or refute the conclusions derived from the present synthesis.

Table 1. Summary of Studies Investigating Perception of Horizontality with Exceptional Populations

Study	Subjects	<u>N</u>		Development	<u>Research Questions Considered</u>	
		M	F		Training/Bottle	Gender
Kelly & Witters (1981)	Gifted Primary $\bar{x}$ Age = 6.11	16	11	Yes	Yes	Yes
	Jr. High $\bar{x}$ Age = 12.8	16	13			
Murphy-Berman & Witters (1987)	Behaviorally Disordered Adolescents, Ages 13-19	21	10	No	Yes	Yes
Murphy-Berman, Witters, & Harding (1985a)	Gifted Hearing Impaired $\bar{x}$ Age = 14.6	5	13	No	Yes	Yes
	Average Hearing Impaired $\bar{x}$ Age = 15.3	8	10			
Murphy-Berman, Witters, & Harding (1985b & 1986)	Intermediate-Aged Hearing Impaired, Ages 9-12	7	8	Yes	Yes	Yes
Murphy-Berman, Witters, & Schillerstrom (1988)	Learning Disabled Elementary	17	7	Yes	Yes	Yes
	Secondary	17	5			

Robertson & Youniss (1969)	Deaf vs. Hearing Younger Deaf $\bar{x}$ Age = 105.6 mo.	8	8	Yes	No	No
	Older Deaf $\bar{x}$ Age = 141.2 mo.	8	8			
Witters-Churchill, Kelly, & Witters (1983), and Witters (1980)	Secondary Deaf Jr. High	16	15	Yes	Yes	Yes

Table 2. Meta-Analysis Results of Studies Which Examined the Gender Question with Exceptional Populations

Study	Description	Sample	p	Magnitude of Gender Differences*		
				Direction	d	n ²
Kelly & Witters (1981)	Gifted primary & Jr. High students: Developmental differences; older males superior on oblique items before training; males and females improved with training	Primary before training	p > .05	None	.08	.15
		after training	p > .05	None	.14	
		Jr. High before training	p < .01	M > F	1.53	
		after training	p > .05	None	.50	
		Total sample				
Murphy-Berman & Witters (1987)	Behaviorally-disordered adolescents: Training improved performance; no gender differences before or after training; after training, more males could state the rule.	Adolescents before training	p > .05	None	.08	NA
		after training	p > .05	None	.11	NA
		(Verbalize the rule)	p < .05	M > F		.16
Murphy-Berman, Witters, & Harding (1985a)	Gifted hearing-impaired students compared to average hearing-impaired students: Females affected more by bottle shape than males	Gifted	p > .05	None	NA	NA
		Average	p > .05	None	NA	NA
Murphy-Berman, Witters, & Harding (1985b/1986)	Intermediate-aged deaf	Males and Females	p = 1.05	None	NA	.12
Murphy-Berman, Witters, & Schillerstrom (1988)	Learning-disabled students: Developmental differences; training improved performance; no gender differences.	Elementary	N.S.	None	NA	NA
		Secondary	N.S.	None	NA	
		Total Sample				

Witters-Churchill, Kelly, & Witters (1983)	Secondary deaf students: No developmental differences; males and females improved with training; no gender differences.	Jr. High	$p > .05$	None	.27	
		Sr. High	$p > .05$	None	.23	
		Total Sample				.02

NA = not applicable or not available

* = reported for oblique bottle positions only

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